

# EGGERS ENVIRONMENTAL, INC.

January 7, 2005

Kelly Dorsey  
California Regional Water Quality Control Board  
San Diego Region  
9174 Sky Park Court, Suite 100  
San Diego, CA 92123-4340

RE: Comments regarding the Mission Valley Terminal Remediation  
Activities and Potential Cleanup Timeline

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Dear Kelly:

As requested, Dr. Paul Johnson and I have prepared our comments regarding past and future cleanup activities and time-frames for the Mission Valley Terminal site to be considered in preparation of your Cleanup and Abatement Order for this site. If you have any questions, please do not hesitate to call myself or Dr. Johnson.

Sincerely,



Margaret R. Eggers, PhD, RG, CHG  
Principal  
Eggers Environmental, Inc.  
Calif RG No. 6232, CHG No. 647

# Comments Regarding Remediation Considerations for the Mission Valley Terminal Site, San Diego, California.

Prepared by Dr. Paul C. Johnson, Arizona State University and Dr. Margaret R. Eggers, Eggers Environmental, Inc. January 7, 2005.

## **1.0 Introduction**

This document has been prepared for the use of the San Diego Regional Water Quality Control Board by Dr. Paul C. Johnson of Arizona State University and Dr. Margaret R. Eggers of Eggers Environmental, Inc. We have reviewed site documents related to investigation and remediation activities which have been conducted since 1992. A list of reports and documents which we have reviewed and referred to is included in Section 6 of this document.

### **1.1. Background**

As a result of historical petroleum storage and distribution operations, soils and groundwater in the vicinity of the Mission Valley Terminal (MVT) in San Diego, CA have been impacted by accidental releases of petroleum liquids. While these leaks and spills originated on the Terminal property, the impacts to soil and groundwater extend off-site to the off-terminal property, including beneath the Qualcomm stadium and surrounding parking lots. This document addresses only impacts in the off-terminal areas, herein referred to as “off-property”. More specifically, this document will focus on practicable remediation tactics, time-frames, milestones, and performance metrics for cleanup of the impacted off-property soils and groundwater. A summary of remedial time-frames and milestones is included in Table 1.

The off-property impacts can be described generally in terms of a source zone defined as the off-property region where liquid petroleum is present in the soil pores, and the dissolved groundwater plume, defined to be that part of the aquifer where dissolved concentrations exceed Maximum Contaminant Levels (MCLs) or other relevant regulatory Action Levels.

The off-property source zone, as defined by soil core sample analyses, dissolved groundwater concentrations, and the appearance of liquid petroleum in groundwater wells, is an area roughly 1000 ft x 600 ft (i.e., Aqui-Ver and Geosyntec, 2001; LFR, 2003j and 2004s). It was estimated from chemical analyses of soil core samples and in situ laser-induced fluorescence (LIF) data that approximately 100,000 gallons (600,000 lbs) of petroleum liquid were present in the soil pores prior to any significant remediation efforts (LFR, 2004e and 2004n; INTERA, 2004). The dissolved groundwater plume, as defined by MTBE and TBA concentrations, extends as far as 4,500 ft down-gradient from the source zone (LFR, 2004s).

To place this site in proper context, the most common petroleum spill sites are those associated with leaking underground storage tanks (LUST) at service stations. The source zone at a LUST site might encompass a 100 ft x 100 ft area (Dahlen, 2004); thus, the MVT source zone is approximately 50 times larger than the source zone at a typical service station spill site. The dissolved MTBE/TBA plume is longer and wider than those at many service station sites (Rice et al., 1995; Happel et al., 1998; Mace et al., 1997; Mace and Choi, 1998; Dahlen, 2004), but dissolved plumes of this length have been observed at other sites (e.g., Naval Base Ventura County; CA, Vandenberg Air Force Base, CA; Santa Monica, CA).

It is common to discuss remedial efforts for these types of petroleum spill sites in terms of separate remedial efforts for the source zone and for the dissolved plume. This document follows that convention and is divided into two sections focusing first on the remediation of the source zone which consists of petroleum-impacted soils, and next on the capture and management of the remaining plume of dissolved groundwater contamination. To avoid confusion, it should be noted that the use of the term “petroleum-impacted soils” in this document refers only to those aquifer and vadose zone materials containing non-aqueous (separate) phase liquid (NAPL) petroleum in the pore spaces.

## **1.2. Summary of Past Remedial Activities**

Remedial activities at the MVT site were initiated in 1992. A summary of remedial actions undertaken by Santa Fe Pacific Pipeline, and subsequently Kinder Morgan Energy Partners and their consultants is included below:

- Late 1992 - 2,366 gallons of LNAPL were recovered by hand bailing or skimming.
- 1993 – 534 gallons of LNAPL were recovered by hand bailing or skimming.
- 1994 – 29 gallons of LNAPL were recovered by a combination of hand bailing or skimming and operation of a groundwater extraction system from May to December, 1994.
- December 1994, a groundwater treatment system discharged petroleum to Murphy Canyon Creek. RWQCB revoked the NPDES permit forcing shut down of the groundwater extraction system.
- September 1996 - NPDES permit issued.
- November 1996 - operation of the groundwater extraction system resumed, 192 gallons of LNAPL recovered.
- December 1996 – Groundwater extraction system shut down due to exceedances for permitted arsenic concentration in NPDES permit. Arsenic occurs naturally in site groundwater at concentrations above permit limits.
- 1997 – 4,821 gallons of LNAPL were recovered by hand bailing or skimming.
- August 1998 – Groundwater extraction system was operational with treated discharge water being trucked to sewer discharge location.

- August 1998 to August 1999 – Groundwater extraction system was operational with discharge water sent to the sewer directly under temporary permit with 150 gpm limit.
- September 1999 to present – Groundwater extraction system discharges to Murphy Canyon Creek.
- October 2001 – Initial soil vapor system installed and operating.
- January 2004 (anticipated) – Property boundary hydraulic containment system installed and operating.

## **2.0 Remediation of Off-Property Source Zone Soils at the Mission Valley Terminal**

### **2.1. Background**

The environmental consulting profession has roughly 20 years of experience with the assessment and remediation of petroleum-impacted sites. This knowledge has been gained from technology development and application at real sites, the results of theoretical analyses, and controlled-release studies at the bench-, macro- and field-scale. The most commonly applied in situ technologies are the aeration-based technologies. These include soil vapor extraction (SVE; e.g., Johnson et al., 1990), bioventing (BV; e.g., Leeson and Hinchee, 1996a,b), and in situ air sparging (IAS; e.g., Johnson et al., 2001). Each involves inducing air flows through impacted soils by withdrawing soil vapors and/or injecting air through wells screened selectively in the vadose or saturated zones. Each method is designed to exploit the volatile nature of typical petroleum product components as well as to enhance the in situ biodegradation of petroleum hydrocarbons under aerobic (oxygen-rich) conditions.

### **2.2. Proposed MVT Off-Property Remediation Plan and SVE Experience to Date**

Kinder Morgan Energy Partners, L.P. and their consultant LFR Levine-Fricke (KM/LFR) have proposed that SVE be the primary source zone treatment technology at MVT (i.e., LFR, 2004c, 2004i, 2004k). To access petroleum liquid residuals currently trapped below the groundwater table, KM/LFR propose coupling SVE with source zone aquifer dewatering via groundwater pumping (with this groundwater pumping also playing a role in the containment and management of the dissolved plume as discussed below in Section 3).

Of note are the following:

- KM/LFR have been implementing SVE since 1999, beginning first with a minimal pilot-scale-sized system, and then in mid-2004 implementing a more aggressive remediation system that draws about 500 ft<sup>3</sup>/min of vapors through a network of vapor extraction wells installed approximately on 100-ft centers (LFR, 2004s).

- There is a small 100 ft x 100 ft portion of the site where a pilot-scale IAS system has been installed and operated, but it is unlikely to be effecting treatment of source zone soils outside of the pilot test area (LFR, 2004c)
- KM/LFR have performed aquifer characterization tests and modeling calculations, and have concluded that sufficient dewatering of the petroleum-impacted soils in the source zone is feasible at the MVT site. KM/LFR estimate that the groundwater table needs to be lowered only a few feet relative to its current position to fully expose all of the petroleum-liquid impacted soils (LFR, 2004v).
- KM/LFR claim the removal of about 430,000 lbs of petroleum (of the initial 600,000 lbs) by SVE alone as of September 30, 2004 (LFR, 2004s).
- Reported SVE system removal rates averaged about 260 lb/d from July through September 2004 (LFR, 2004s).
- The MVT subsurface is complex and composed of layers of fine-, medium-, and coarse-grained soils, but still is sufficiently permeable to air flow to achieve significant volatilization and elevated oxygen concentrations in soil gas. With a few exceptions, elevated near-atmospheric oxygen levels have been detected in multi-depth soil gas clusters placed throughout the target treatment zone, even in the lower permeability soils (LFR, 2004s).

### **2.3. Assessment of Future Performance Expectations Based on SVE System Performance to Date and Knowledge Gained from Experience and the Technical Literature**

The following is a summary of thoughts relevant to the establishment of remediation performance expectations for the MVT site. Each represents an independent assessment of practicable remediation time frames using the available site characterization information, SVE performance data available to date (discussed briefly above in §2.2), and knowledge gained from the literature and experience. As discussed below, these “multiple lines-of-evidence” suggest that a source zone remediation time frame of about five years is practicable if the SVE system performance is optimized.

- Assuming that the cumulative removal estimates are correct (430,000 lbs by SVE, 38,000 lbs by free-product recovery, and 13,000 lbs by groundwater extraction), and the initial mass estimate is reasonably accurate (about 600,000 lbs of petroleum liquid in soil), then roughly 120,000 lbs remains. Furthermore, if the SVE system were to continue to average 260 lb/d removal, then the remaining petroleum would be removed in a one- to two-year time frame.

- The SVE system has been operated at only one-half the total flow rating for the vapor treatment system (500 of the 1000 ft<sup>3</sup>/min design capacity, LFR, 2004u). Thus, there is the potential to double the removal rate by increasing the total vapor extraction flow rate to the 1000 ft<sup>3</sup>/min design capacity.
- With a few exceptions, elevated near-atmospheric oxygen levels have been detected in multi-depth soil gas clusters placed throughout the target treatment zone, even in the lower permeability soils. The bioventing literature (e.g., Leeson and Hinchee, 1996a,b) suggests that biodegradation rates in the 2 to 20 mg-hydrocarbons/kg-soil/d range are achievable under these field conditions. Considering that most source zone total hydrocarbon concentrations in soil sampled at the MVT site have been <5000 mg-hydrocarbons/kg-soil (Aqui-ver and GeoSyntec, 2001; LFR, 2003j and 2004i), aerobic biodegradation could result in remediation of the soil in one to seven years at the rates cited in the literature.
- Typical remediation projects involving the aggressive application of aeration-based technologies at LUST sites are generally of one- to three-year durations. While the MVT site is larger, a proportionally-sized remediation system would be expected to perform similar to a smaller one at a LUST site.
- For gasoline, the theoretical minimum airflow requirement is about 100 L of air per gram of gasoline to achieve >90% removal by volatilization (Johnson et al., 1990). Assuming that 120,000 lbs of petroleum remain, this translates to a requirement of about  $2 \times 10^8$  ft<sup>3</sup>; for reference, this volume of vapor is pulled through the soil every 130 days by an SVE system operating at a total flow rate 1000 ft<sup>3</sup>/min.

The information presented above supports a practicable target remediation time frame of about five years (either by volatilization or by aerobic biodegradation), if steps are taken to optimize the SVE system performance over this time frame as discussed below.

#### **2.4. Critical Issues Relevant to Optimizing Remediation by Combined SVE/Dewatering**

As stated above, a practicable source zone remediation time frame of five years is achievable if the SVE system performance is optimized. The following are of relevance to the optimization of the combined SVE/dewatering system:

- The deepest depth of petroleum impacts to soils in the source zone is not known with great confidence. Soil core sample recovery challenges have led to a reliance on CPT/LIF data, and the confidence in relying on the LIF data is arguably low as the LIF-response vs. TPH concentration data set shows no clear correlation (LFR, 2004m). KM/LFR have also argued that the current groundwater elevation is within a few feet of historic lows and that impacted soils are not expected below the depth of the historic low groundwater elevation. KM/LFR have agreed with the

City of San Diego to conduct additional coring to better define the depth of soil impacts.

- One way to compensate for the uncertainty in the deepest depth of impacted soils would be to draw the water table down a few feet deeper than the suspected depth. If this is practicably achievable, then this option should be pursued.
- For reference, SVE system flow rates for typical service station sites are about 100 to 200 ft<sup>3</sup>/min per site, so even at the total design capacity of 1000 ft<sup>3</sup>/min. the total capacity of the MVT SVE system is currently only about 1/10<sup>th</sup> or less of what would be expected based only on the size of the MVT source zone relative to the size of a service station spill site (about a 50:1 area ratio). It is possible, however, that the 1000 ft<sup>3</sup>/min flow rate could be sufficient (as suggested by the minimum flow requirement discussion above and soil gas oxygen data), but it is critical that SVE wells are designed to ensure that this flow be focused on the target treatment zone.
- The screened (perforated) intervals of the existing SVE wells terminate about five feet above the current water table (which will be lowered by several feet). Thus, the screened intervals of existing wells are not designed to maximize and direct air flow down through the target treatment zone. Any new wells should be installed with screens spanning the full target treatment zone, and the performance of the existing wells needs to be assessed to ensure that they can achieve the desired flow conditions.
- Similarly, the deepest soil gas monitoring probes also extend only down to within three to five feet of the current water table and are not designed to monitor the deeper soil zone that will be exposed by dewatering. Thus, deeper soil gas sampling points are needed throughout the target treatment zone.
- The spacing of vapor extraction wells at the MVT site (100 ft spacing) is about twice the spacing of SVE wells at typical service station spill sites. Thus, closer well spacing may be necessary to achieve the desired performance (this will be clear from the performance monitoring data).
- The spatial density of vapor extraction wells is even less on the east side of the source zone and along San Diego Mission Road. Thus, additional wells are needed, even with the current 100-ft SVE well-spacing design.

## 2.5 Metrics and Milestones for the SVE/dewatering System

The following section presents activities, metrics, milestones and contingency plans that are likely necessary for achieving the practicable remediation of the off-property source zone within the time frame suggested above.

### 2.5.1 0 to 3 Month Time Frame

In this time frame, the following should be accomplished:

- Upgrading the SVE infrastructure to achieve the cumulative system vapor flow rate of 1000 ft<sup>3</sup>/min from the SVE wells (the original vapor treatment system design flow rate). This will be verified through the summation of measured flows from individual vapor extraction wells and a total (pre-dilution) vapor system flow rate measurement. Communications from KM/LFR suggest that this is in progress as of the fourth quarter of 2004 (i.e., LFR, 2004u).
- Weekly (at a minimum) monitoring of extracted soil gas total hydrocarbon concentrations<sup>1</sup>, vapor flow rates, and vacuums at each vapor extraction well. On a monthly basis, individual well samples should be analyzed by GC/FID or GC/MS to determine the relative contributions of <C<sub>4</sub>, C<sub>4</sub> – C<sub>8</sub>, C<sub>8</sub> – C<sub>12</sub>, and >C<sub>12</sub> hydrocarbon fractions to the TPH composition<sup>2</sup>.
- Soil coring in the source zone, as promised by KM/LFR to the City of San Diego, to more confidently define the deepest extent of soil impacts (City of San Diego/KM, 2004). This sampling plan should be carefully designed to support or refute the KM/LFR assertion that soil impacts extend at most to a depth that is only one or two feet deeper than current water table levels. This will be verified through inspection of tabulated soil core chemical analyses data. Chemical analysis should include GC/MS or GC/FID to determine the relative contributions of <C<sub>4</sub>, C<sub>4</sub> – C<sub>8</sub>, C<sub>8</sub> – C<sub>12</sub>, and >C<sub>12</sub> hydrocarbon fractions in the initial soil hydrocarbon residuals (this information would then provide a good benchmark for comparison with future soil coring data and the soil gas monitoring discussed below as a shift to a heavier hydrocarbon composition with time is expected). Lab-scale leachate tests should be conducted on the most impacted soil cores to provide a benchmark for assessing changes in time with the potential groundwater quality impacts.
- Installation of additional soil vapor extraction wells in off-property source zone areas having a relatively low coverage of vapor extraction wells, for example: a) along San Diego Mission Road, and b) the region west of RW-31, RW-32, and RW-33, and c) west of RW-3. This is to be verified by drawing a plan-view map

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<sup>1</sup> Total hydrocarbon concentrations can be measured with field instruments (FID) as long as periodically (once every four sampling events) field samples are sent to a laboratory for confirmation.

<sup>2</sup> Once GC/MS or GC/FID is selected as the analytical method, it should remain consistent through the life of the project.

showing the source zone outline along with all current and proposed wells and their associated estimated zones of treatment having radii of 50-ft, and ensuring full-spatial coverage of the estimated off-property source zone area.

The new vapor extraction wells should be designed to maximize and direct soil gas flow through the deeper part of the target treatment zone, especially the soils to be exposed by dewatering. This will require longer well screens than currently used, in order to span the target treatment zone.

- Installation of additional soil gas monitoring points, at a spatial density that is at least half the density of the soil vapor extraction wells, and being located so that at least half the monitoring points are placed in regions that are approximately 40 to 50 ft away from any soil vapor extraction well (on the edge of the design radius of influence). All monitoring locations (either current or planned) should have a deep soil gas monitoring point located about one foot above the deepest depth of impacted soils as determined by the soil coring discussed above. KM/LFR should consider the possibility of installing real-time in situ oxygen sensors at critical depths and locations to ensure adequate oxygen supply.
- Continued sampling of all soil gas monitoring points on at least a bi-weekly basis for total hydrocarbon concentrations and respirometry gases (oxygen, carbon dioxide, nitrogen). Some (about 25% or more, and a consistent set) of the higher concentration samples should be analyzed by GC/FID or GC/MS to determine the relative contributions of  $<C_4$ ,  $C_4 - C_8$ ,  $C_8 - C_{12}$ , and  $>C_{12}$  hydrocarbon fractions to the overall TPH composition.
- Perform an in situ respirometry test quarterly using all soil gas monitoring points (Hinchee and Ong, 1992; Leeson and Hinchee, 1996a, b), in which the SVE system is turned off for three days, and soil gas monitoring points are sampled and analyzed in the field for oxygen/carbon dioxide/nitrogen at four-hour (or less) intervals.
- Initiation of the pumping for the groundwater dewatering system and bi-weekly monitoring of water levels throughout the off-property treatment zone.

### 2.5.2 3 to 12 Month Time Frame

In this time frame, the following should be accomplished:

- Operation of the SVE system at a cumulative system vapor flow rate of 1000 ft<sup>3</sup>/min from the SVE wells. This will be verified weekly through the summation of measured flows from individual vapor extraction wells and a total (pre-dilution) vapor system flow rate measurement.
- Weekly (at a minimum) monitoring of extracted soil gas total hydrocarbon concentrations, vapor flow rates, and vacuums at each vapor extraction well. On a

monthly basis, individual well samples should be analyzed by GC/FID or GC/MS to determine the relative contributions of  $<C_4$ ,  $C_4 - C_8$ ,  $C_8 - C_{12}$ , and  $>C_{12}$  hydrocarbon fractions to the TPH composition.

- Continued sampling of all soil gas monitoring points on at least a bi-weekly basis for vacuum, hydrocarbon concentrations, and respirometry gas concentrations (oxygen, carbon dioxide, nitrogen). Some (about 25% or more, and a consistent set) of the higher concentration samples should be analyzed by GC/FID or GC/MS to determine the relative contributions of  $<C_4$ ,  $C_4 - C_8$ ,  $C_8 - C_{12}$ , and  $>C_{12}$  hydrocarbon fractions.
- Demonstrate that vapor flow rates from the well network are optimized weekly to achieve the maximum volatilization rate, and bi-weekly that each soil gas monitoring location is under vacuum at all depths and is exposed to vapor flow (i.e., not water-saturated), and that oxygen concentrations exceed 10% v/v at all depths of each soil gas monitoring location.
- Perform an in situ respirometry test quarterly using all soil gas monitoring points (Hinchee and Ong, 1992; Leeson and Hinchee, 1996a, b), in which the SVE system is turned off for three days, and soil gas monitoring points are sampled and analyzed in the field for oxygen/carbon dioxide/nitrogen at four-hour (or less) intervals.
- Achieve the target dewatering in the off-property source zone (at least one to two feet below the depth of deepest soil impacts), as verified by groundwater level measurements and the ability to draw vapors from the deepest soil gas sampling points.
- System modifications (i.e. increased well density) or alternate technology selection needs to be pursued if it is determined that any of the following cannot be met: (a) draw-down of the water table to expose all impacted soils, (ii) oxygen concentrations in soil gas at all depths  $>10\%$  v/v, and (iii) vacuums recorded for all soil gas monitoring points.

### 2.5.3 12 to 60 Month Time Frame

In this time frame, the following should be accomplished:

- Operation of the SVE system continues at a cumulative system vapor flow rate of  $1000 \text{ ft}^3/\text{min}$  from the SVE wells, unless it can be shown that the remediation rate via aerobic biodegradation greatly exceeds that from volatilization. If that is the case, then the vapor extraction flow rates can be reduced to levels sufficient to ensure  $>10\%$  v/v oxygen at all soil gas monitoring points. Extraction flow rates will be verified through the summation of measured flows from individual vapor extraction wells and a total (pre-dilution) vapor system flow rate measurement.

- Monitoring (weekly at a minimum) of extracted soil gas total hydrocarbon concentrations, vapor flow rates, and vacuums at each vapor extraction well. On a monthly basis, individual well samples should be analyzed by GC/FID or GC/MS to determine the relative contributions of  $<C_4$ ,  $C_4 - C_8$ ,  $C_8 - C_{12}$ , and  $>C_{12}$  hydrocarbon fractions to the TPH composition. In this time period, a composition shift towards heavier components should be evident in the data.
- Continued sampling of all soil gas monitoring points on at least a bi-weekly basis for vacuum, hydrocarbon concentrations, and respirometry gas concentrations (oxygen, carbon dioxide, nitrogen). Some (about 25% or more, and a consistent set) of the higher concentration samples should be analyzed by GC/FID or GC/MS to determine the relative contributions of  $<C_4$ ,  $C_4 - C_8$ ,  $C_8 - C_{12}$ , and  $>C_{12}$  hydrocarbon fractions to the TPH composition.
- Demonstrate that vapor flow rates from the well network are optimized weekly to achieve the maximum volatilization rate, and bi-weekly that each soil gas monitoring location is under vacuum at all depths and is exposed to vapor flow (i.e., not water-saturated), and that oxygen concentrations exceed 10% v/v at all depths of each soil gas monitoring location.
- Perform an in situ respirometry test quarterly using all soil gas monitoring points (Hinchee and Ong, 1992; Leeson and Hinchee, 1996a, b), in which the SVE system is turned off for three days, and soil gas monitoring points are sampled and analyzed in the field for oxygen/carbon dioxide/nitrogen at four-hour (or less) intervals.
- Maintain the target dewatering in the off-property source zone (at least one to two feet below the depth of deepest soil impacts), as verified by groundwater level measurements and the ability to draw vapors from the deepest soil gas sampling points.
- At least every two years, soil sampling should be conducted in select regions to assess the progress of remediation. Analyses should include total residual hydrocarbon concentrations, composition of total residual hydrocarbon (i.e., determine the relative contributions of  $<C_4$ ,  $C_4 - C_8$ ,  $C_8 - C_{12}$ , and  $>C_{12}$  hydrocarbon fractions), and leachate tests conducted on impacted soil cores to assess changes in time with the potential groundwater quality impacts.

#### 2.5.4 Metrics of Successful Progress

Successful progress towards remediation will be assessed through the following metrics:

- Consistency in maintaining target vapor extraction rates (i.e., 1000 ft<sup>3</sup>/min from SVE wells, or the minimum flow rate necessary to achieve 10% v/v oxygen in all soil gas monitoring points when removal by aerobic biodegradation is shown to greatly exceed removal by volatilization by a factor of 10).

- A reduction in the optimized mass removal rate by volatilization with time (the total removal rate of non-methane hydrocarbons by volatilization should decrease to <1 lb/d).
- A shift in the composition of extracted vapors towards heavier carbon fraction ranges with time (compounds of concern are in the <C<sub>8</sub> fraction and the contribution of <C<sub>8</sub> fraction non-methane hydrocarbons should be reduced to <1% of the total vapor composition).
- A shift in the composition of soil gas samples collected from in situ monitoring points towards heavier carbon fraction ranges with time (compounds of concern are in the <C<sub>8</sub> fraction and the contribution of <C<sub>8</sub> fraction hydrocarbons should be reduced to <1% of the total vapor composition).
- A reduction in concentrations of total hydrocarbons in the soil gas monitoring points (these should be reduced to <0.01 mg-TPH/L-vapor).
- A reduction in oxygen utilization rates measured during the system-wide in situ respirometry tests (to less than 1 mg/kg/d).
- Reductions in concentrations of chemicals of concern in soil core leachates (to less than 10 times the target groundwater concentration for each chemical in most samples).

#### 2.5.5 Post-Remediation Assessment

When the operation and monitoring data suggest that remediation goals have been met, the following should be conducted:

- The SVE system should be turned off and the rebound of soil gas concentrations should be monitored in all soil gas monitoring points over a two-month period, with samples collected on a weekly basis. Minimal rebound (increases in vapor concentrations of less than five times the pre-shut-down levels of <0.01 mg-TPH/L-vapor) should be observed with negligible contributions from <C<sub>8</sub> components for successful remediation (these components comprise <10% of the TPH in vapors).
- Soil sampling should be conducted to assess the impact of remediation, in terms of total residual hydrocarbon concentrations, total residual hydrocarbon composition, and leachate tests conducted on impacted soil cores to assess likely impacts to groundwater quality. Leachate concentrations of target compounds should be less than levels of concern in most samples, and less than 10 times the target concentrations for each chemical in all samples.
- If the first two bullet items suggest successful remediation, then aquifer pumping rates can be reduced to what is necessary for dissolved plume containment and

recovery. As this happens, groundwater in the source zone should be sampled on a quarterly basis.

It should be noted that the effect of remediation on groundwater quality impacts cannot be fully assessed until groundwater pumping ceases and groundwater levels are allowed to rise back to natural levels.

### **3.0 Containment and Management of the Off-property Dissolved Plume at the MVT Site**

At present, two groundwater pumping wells have been installed downgradient of the off-property residual LNAPL area to provide containment of the dissolved phase contaminants, predominantly MTBE and TBA. These wells, RW-8 and RW-9, were completed in November, 2002. In the last quarter reported, RW-8 and RW-9 were pumped an average of 37 and 34 gallons per minute (gpm) respectively (LFR, 2004s). Initial concentrations of MTBE and TBA were 1,200 µg/L and 640 µg/L, respectively, in RW-8; and 350 µg/L and 78 µg/L, respectively, in RW-9. Benzene has apparently been detected only once, in the initial sample of effluent from RW-8 at a concentration of 0.33 µg/L. RW-8 and RW-9 were turned off for approximately four months between October 2003 and February 2004.

Capture of the MTBE/TBA plume is claimed by KM/LFR based on groundwater level measurements (Figures 3, 4 and 5, LFR, 2004s). Based on this KM/LFR assumption, the capture zone for extraction wells RW-8 and RW-9 extends about 1000 feet downgradient of RW-9. Therefore, the remainder of the MTBE/TBA plume which extends to the San Diego River and down and across the river to beyond Mission City Parkway remains to be addressed. Since the two segments of the dissolved plume – the “captured” portion and the uncaptured portion are essentially two separate issues, we will address them separately in this document.

#### **3.1. Potential Remedial Timeframe**

Review of numerous general and site-specific case studies for California and other states emphasizes that the apparent size of the release, and resulting plume length, at the Mission Valley site makes this one of the larger MTBE impacted areas in the state. Therefore, although many typical gasoline station-scale cleanups have progressed from discovery to closure in a few years, it is reasonable to expect that cleanup of the dissolved plume at the Mission Valley site would require a longer time frame.

While this site does constitute one of the larger examples of fuel and MTBE contamination, it is also evident that for the past 20+ years, site assessment and cleanup consultants, as well as academic scientists, have been working on understanding and cleaning up such sites. As such, there is a significant history of fuel cleanups which

demonstrate that the well-tested methods which have been implemented at this site can be effective when applied aggressively.

### **3.2. Metrics and Milestones for Portion of Groundwater Plume Presumed to be Within the RW-8 and RW-9 Capture Zone**

The volume of groundwater in the plume downgradient from the off-property LNAPL source area was estimated at 287,200,000 gallons based on the May 2004 interpreted MTBE plume contours (LFR, 2004n). Of that volume, less than half, or 128,160,000 gallons, is estimated to be within the capture area affected by RW-8 and RW-9 (LFR, 2004n). Assuming the two extraction wells pump at a combined rate of 60 gpm, the residence time for one affected pore volume is estimated at four years (LFR, 2004n). Groundwater modeling conducted by KM/LFR has also suggested that under current pumping conditions, the combination of groundwater extraction and natural attenuation processes will result in this area of the plume being at or below 10 µg/L MTBE within approximately 5 years (2010, LFR, 2004d). It is likely that the natural biological degradation of not only MTBE but also the primary degradation product TBA will play a large part of in contaminant reduction.

Since the LNAPL source area is still present and still in contact with groundwater and providing a continual source for contaminants, RW-8 and RW-9 will serve only to contain, and not remediate, this portion of the plume until the source area no longer contributes contaminants to the groundwater. Therefore, one might anticipate that remediation of the contaminated groundwater within the RW-8 and RW-9 capture area will not begin until the groundwater within the off-property LNAPL area is lowered to beneath the residual LNAPL.

#### **3.2.1. 0 to 6 months time frame**

- During this time frame, the property boundary containment extraction wells will be put in operation. These wells are designed to both provide containment of on-property LNAPL which remains from the original spill and that of future LNAPL releases, and allow the groundwater table beneath the off-property residual LNAPL source area to be lowered sufficiently to allow the SVE system to effectively remove residual LNAPL currently in the vadose and saturated zones. To date, extraction wells RW-3A to RW7 appear to have provided sufficient capture of the dissolved benzene plume within the off-property residual LNAPL area. Although benzene concentrations in groundwater are currently as high as 21,000 µg/L within the center of the off-property LNAPL area, they rapidly decrease to <5 µg/L just beyond the row of extraction wells (Figure 8, LFR, 2004s).

It will be important to maintain capture of the benzene plume as the water table is lowered and pumpages are redistributed between the various extraction wells. Therefore, it is appropriate to request that groundwater levels be collected within the affected area of the groundwater extraction wells more frequently than the

current quarterly monitoring to demonstrate continued hydraulic capture. It is probable that KM/LFR already have similar plans in place as part of their start-up and initial operation of the property boundary wells. KM/LFR may wish to propose a reporting schedule to the RWQCB based on their current plans which would satisfy this concern.

- Once the on-property hydraulic barrier has provided sufficient drawdown in the residual LNAPL zone, it will be necessary to evaluate the effects to the RW-8 and RW-9 containment and to verify capture is being maintained. Given the additional volume of water to be extracted upgradient based on recent extraction well testing (LFR, 2004v), pumping rates for RW-8 and RW-9 may require adjustment to accommodate the groundwater being withdrawn from the system upgradient and provide appropriate capture. KM/LRF should propose a reporting schedule to the RWQCB based on their current plans which would satisfy this concern.
- As noted below in the Data Gaps section, at this time capture by RW-8 and RW-9 is being assumed based on a limited number of monitoring wells, especially to the east of RW-8 and RW-9. KM/LFR have indicated that additional wells are being considered in this area, and this would help to demonstrate the efficacy of RW-8 and RW-9 pumping and verify the assumed capture. As there are currently no data to evaluate groundwater flow beneath the stadium, and stadium personnel have indicated that there have been groundwater wells previously installed in the area beneath the stadium, every reasonable effort should be made to acquire data on groundwater elevation and flow beneath the stadium. These additional wells should be installed within this 0-6 month window.

### 3.2.2. 6 to 60 Month Time Frame

- During this time period, the property boundary containment wells, groundwater extraction wells RW-3A through RW-7, and the SVE system will be operating in concert to address the residual off-property LNAPL source zone. The performance of extraction wells RW-8 and RW-9 should be evaluated on a quarterly basis, as part of the quarterly groundwater monitoring program. Adequacy of performance will be demonstrated based on:
  - groundwater flow data from the expanded groundwater monitoring system such that the additional monitoring wells provide data to support groundwater capture by RW-8 and RW-9 both west of the stadium as well as beneath and east of the stadium. Capture will be demonstrated by plots of water elevation contours showing hydraulic gradients and flow directions both cross- and downgradient of the extraction wells.
  - decreasing contaminant concentration trends adjacent to and downgradient of RW-8 and RW-9 will also support capture and remediation of this portion of the plume by RW-8 and RW-9.

- monitoring of biodegradation indicators such as dissolved oxygen, pH, alkalinity, methane, ferrous iron, sulfate and nitrate. Although there is evidence that some degree of biological activity is occurring in some portions of the plume, the actual rates and limiting processes are poorly understood. Additional data should help elucidate the actual mechanisms which may be operating in different portions of the plume. The study by Scow (2004) illustrated the importance of oxygen in encouraging biodegradation using the native in situ microbial community, however it has not been demonstrated that the environment within the plume is well-oxygenated. KM/LFR should demonstrate a better understanding of the natural biodegradative processes before assuming it is a source of the concentration reductions within the plume. Concentration trends for MTBE and the degradation by-product TBA can be used to demonstrate attenuation within this portion of the plume, provided that the data is of sufficient spatial and temporal density.

If it is apparent based on unchanging or increasing groundwater concentrations or water level data that hydraulic capture is not complete or remediation is not progressing at the anticipated rate, additional extraction wells may be required.

#### 3.2.3. At 60 Months

It is anticipated within the 60-month time period, groundwater concentrations in the plume downgradient of the off-property LNAPL source area and within the RW-8 and RW-9 capture zone will have been reduced to below MCLs. This is based upon calculations of the volume of water removed during that time period, estimates of natural degradation rates described by LFR, and groundwater modeling (LFR, 2004d and 2004v). Based on the metrics described above in 3.2.2, LFR may wish to propose to the RWQCB that pumping at RW-9 be gradually turned off.

It is also anticipated that at or before the end of the 60-month time period, remedial efforts in the off-property residual LNAPL area will have been successful, and the SVE system will no longer operate. At that time, it is also anticipated that groundwater extraction from the RW3A-RW7 wells, and/or the property boundary containment wells, will be reduced to allow groundwater levels to rebound to more natural levels. As water levels recover to above intervals where residual LNAPL was present, it is probable that some re-bounce may occur and contaminant concentrations may increase. Therefore, it is anticipated that extraction wells in the immediate area of the LNAPL source will continue pumping to capture any additional groundwater plume as a result of rebound.

#### 3.2.4. At 60-96 Month Time Frame

Within this 5-8 year time frame, it is anticipated that groundwater concentrations in the area of the former off-property residual LNAPL source area can be reduced to MCLs. In order to achieve this goal, it is important that the SVE-phase of remediation of the residual LNAPL be as thorough as technically practicable.

Similar to the metrics discussed for termination of pumping at RW-9, it should be appropriate at this time period to evaluate ceasing operation of RW-8. Assuming that groundwater concentrations have been reduced to MCLs between RW-8 and the RW-3A to RW-7 extraction wells, and that the RW-3A to RW-7 wells are still providing full hydraulic capture in the off-property residual LNAPL area, it may be appropriate for LFR to request discontinuing operation of RW-8. However, the RW-3A to RW-7 wells should continue to operate throughout this time period to capture any groundwater re-contaminated by the LNAPL source area after the SVE system is turned off and groundwater levels rise.

#### 3.2.5. Post-96 Month Time Frame

If groundwater MCLs can not be achieved within the former off-property residual LNAPL source area before this time frame, then at a minimum it must be demonstrated that the on-property groundwater extraction wells which will continue to operate as the on-property containment, can also provide sufficient capture to prevent any downgradient migration of contaminants emanating from the off-property residual LNAPL source area. If the property boundary containment wells do not provide containment in this area it may be necessary to operate one or all of the RW-3A to RW-7 extraction wells on a long-term basis.

### 3.3. Metrics and Milestones for Remainder of Groundwater Plume

The volume of groundwater in the plume downgradient from the off-property residual LNAPL source area was estimated at 287,200,000 gallons based on the May 2004 interpreted MTBE plume contours (LFR, 2004n). Of that volume over half, or 159,040,000 gallons, is estimated to be downgradient of the capture range of any extraction well at the MVT (LFR, 2004n). Groundwater modeling conducted by KM/LFR purports to show that within approximately 5 years, the majority of this area of the plume will be at or below 10 µg/L MTBE (LFR, 2004d). However, this estimate is based on optimistic rates of natural attenuation (including biological activity) and a limited well network in this distal portion of the plume. In addition, all future assessment of remedial effectiveness should include the reduction of the primary MTBE degradation by-product TBA, as well as subsequent degradation compounds.

#### 3.3.1. 0 to 18 month time frame

We understand that KM/LFR is currently preparing a plan to install a more robust monitoring well network in this general area, most likely a row of multi-level well clusters which would be located upgradient and parallel to a line running between existing well clusters R21 and R30. The data from these wells will be important for several reasons:

- Based on early close-spaced groundwater samples (TRC, 2000) and wide fluctuations in groundwater concentrations in several wells in this area, it appears

that the MTBE/TBA plume is quite narrow in this portion of the plume, possibly due to preferential flow along a former channel or gravel.

- Well cluster R21 has shown wide variations in MTBE concentrations in all intervals within the well cluster. Reductions in MTBE concentrations have also been followed by increasing TBA concentrations, again in each interval within the well cluster. This may indicate that some form of bio-transformation is taking place which will be helpful in the natural attenuation of this portion of the plume. However, a recent bench study with samples collected from both site cores and sediment samples from the San Diego River only suggested that some organisms with the potential to degrade MTBE are present, however their bioremedial activity may be oxygen dependent and not distributed uniformly throughout the plume. Therefore it is difficult to judge how effectively this portion of the plume will attenuate. Additional data from the planned well transect should yield greater understanding of both the actual dimensions of the MTBE/TBA plume, and assessment of the effectiveness of potential biological activity.
- Within the 18-month time frame, the additional well transect should be installed and sampled quarterly.

#### 3.3.2. Post-18 month time frame

- At the end of this period, LFR should provide the RWQCB with a letter report or technical memo assessing the status of this portion of the plume, and an assessment of whether or not the remaining contamination will in fact attenuate within the 5-year time frame suggested by current groundwater modeling.
- Groundwater concentration trends of MTBE and TBA downgradient of R-21 should remain constant initially, and should actually decrease to ND or MCLs at the extreme portions of the plume within the 18-month time frame. If concentrations fail to decrease or begin to increase, additional active remedial measures may be required such as one or more additional groundwater extraction wells.

LFR should provide the RWQCB with a letter report or technical memo assessing the effectiveness of natural attenuation within the plume downgradient of the RW-9 capture area, especially the area surrounding R-21 well cluster. This should include any evidence of bioattenuation and address both MTBE and TBA. Assuming that additional active remedial measures are not deemed necessary at the time of this evaluation, LFR should re-visit this evaluation as part of the quarterly monitoring report which should document continual attenuation.

#### 3.3.3. Contingency for Potential Municipal Well Installations Adjacent to San Diego River

The City of San Diego has proposed that at some time in the near future, they may install one or more groundwater production wells somewhere along the San Diego River within the Qualcomm Stadium parking area and property (CH2Mhill, 2003; City of San Diego Water Department, 2004). Given the changing concentrations and configuration of the current MTBE/TBA plume, and the uncertainties regarding the time, actual location, construction or pumping rates for such a well, it is impossible to gauge with certainty what impacts the MVT dissolved plume may have on a groundwater production well. The currently planned monitor well transect which has been discussed by KM/LRF should provide a helpful tool in evaluating this issue at such time as a well location, design etc. is decided upon by the City of San Diego. If at that time, a technical evaluation such as a “flux calculation” suggests that MTBE/TBA from the MVT groundwater plume will be captured by the municipal well, well head treatment should be considered as a remedial option.

#### 4.0 Existing Data Gaps

- **Identification of depth of residual LNAPL impacts below the water table:** LFR has not specifically identified the depth to which they believe residual LNAPL occurs beneath the water table, and the amount of reduction in the water table necessary to expose those areas (after considering uncertainty and spatial variability in the site data). This is critical since all remedial measures which they have considered apply only to unsaturated (naturally or dewatered) materials. Therefore, there is no recourse to their cleanup if the water table is not sufficiently lowered.
- **Understanding of residual LNAPL in area outside of current remediation system is incomplete.**
  - LFR clearly agrees that R-11 is both an area of residual LNAPL and outside or at the limits of the current SVE system.
  - LIF/CPT data does not extend out to this area. On the map showing % LIF response, the closest LIF locations to R-11 are actually “ND”. On the map showing Thickness of LIF response, the closest LIF locations to R-11 are “NA” or 5 feet or less.
  - R-11 was installed in 1999. Free product first appeared in R-11 in May of 2001 (0.7’), and was last seen in May of 2002. Benzene concentrations had been generally increasing prior to the appearance of FP from 280 µg/L in 1/99 to 6,400 µg/L in 11/00 (well not monitored in 2/01). This suggests, since R-11 is downgradient from the main LNAPL area, that free product was migrating toward, and possibly beyond, the location of R-11 prior to the installation of the extraction wells
- **Little plume or groundwater flow definition beneath or east of the stadium:** The area east of and beneath the stadium and east of RW8 and RW9, has no monitoring wells. The lack of wells in this area and beneath the stadium means that there is no actual data to support that RW-8 and RW-9 are providing adequate capture. In addition, if the plume is actually migrating east then there are no wells to

monitor the plume here. This becomes more important in the future as the total volume of pumping will likely be re-distributed within the system to increase pumping in the main source area and lower the water table there to facilitate remedial efforts. As pumpages are adjusted, it is important that adequate capture be maintained by RW-8 and RW-9. Increases in MTBE in shallow well R-17 sheds some doubt on the efficacy of the RW-8 and RW-9 capture. The lack of any intermediate or deep alluvial monitor wells at R-17 means that there is no data for the deeper portion of the aquifer, in this an area where MTBE/TBA concentrations tend to be greater deeper in the aquifer.

In addition, further out in the remediation time line, RW-9 will be turned off before RW-8 as part of the latter phase of the remediation. When this happens, it will be even more important to monitor groundwater concentrations and the flow field around RW-8 to ensure there are no adverse effects of halting pumping at RW-9.

- **Lack of understanding regarding MTBE biodegradation:** Monitoring well data indicates that some degradation is taking place (primarily increased TBA concentrations), but the data is limited and of low spatial and temporal density. In addition, the biodegradation of TBA (an MTBE biodegradation product) has not been demonstrated. If MNA is to be credited with some portion of the reduction of the contamination in the dissolved plume, and if it is to play a role in either the remedy itself, then it should be better understood.

## 5.0 Summary

The attached Table 1 summarizes the various milestones and requirements for cleanup within 1) the off-property source area of residual LNAPL, 2) the area of the MTBE/TBA groundwater plume within the RW-8 and RW-9 assumed capture zone, and 3) the area of the MTBE/TBA groundwater plume downgradient of the influence of RW-9.

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**Table 1 - Summary of Remedial Milestones – Mission Valley Terminal**

<b>Cleanup Goal</b>	<b>Cleanup Method</b>	<b>Cleanup Task</b>	<b>Cleanup Task Progress Metric</b>	<b>Contingency</b>	<b>Time to Completion</b>
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System upgrade	Upgrade SVE infrastructure to achieve the system design flow rate of 1000 ft <sup>3</sup> /min from the soil vapor extraction wells.	None. KM/LFR indicate that this is in progress as of end of 2004.	0 to 3 Months
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System evaluation and monitoring	No less than weekly monitoring of total hydrocarbon concentrations <sup>1</sup> , vapor flow rates and vacuum at each SVE well.  Sample each SVE well monthly and analyze by GC/FID or GC/MS <sup>2</sup> to determine composition changes with time (as assessed by hydrocarbon fractions).	n/a	0 to 3 Months
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System coverage improvements	Installation of additional SVE wells in off-property source zone areas having relatively low coverage of vapor extraction wells including 1) along SD Mission Rd; 2) area west of RW-31, RW-32 and RW-33; 3) west of RW-3.  Additional wells should be designed to maximize flow directed through the target treatment zone, including soils to be exposed by dewatering.	Verify coverage by providing plan-view map showing all current and proposed wells with associated influence zones of 50-foot radii. If full spatial coverage of the lateral extent of the estimated off-property source zone area is not adequately covered, additional SVE wells may be needed.	0 to 3 Months

<sup>1</sup> Total hydrocarbon concentrations can be measured with field instruments (FID) as long as periodically (once every four sampling events) field samples are sent to a laboratory for confirmation.

<sup>2</sup> Once GC/MS or GC/FID is selected as the analytical method, it should remain consistent through the life of the project.

**Table 1 - Summary of Remedial Milestones – Mission Valley Terminal**

Cleanup Goal	Cleanup Method	Cleanup Task	Cleanup Task Progress Metric	Contingency	Time to Completion
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System coverage improvements	Installation of additional soil gas monitoring points: 1) at a spatial density at least half the density of the SVE wells 2) located such that at least half of the monitoring points are placed in locations ~40 to 50 ft away from any SVE well. 3) <u>all</u> monitoring locations (including existing) to have a deep soil gas monitoring interval located about one foot above the deepest depth of impacted soils as determined by the combined current soil data and planned soil sampling as described below. 4) consider possibility of installing real-time, in situ O <sub>2</sub> sensors at critical depths and locations to ensure adequate O <sub>2</sub> supply and coverage.	n/a	0 to 3 Months
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System coverage monitoring	Continued sampling of all soil gas monitoring points: 1) at a minimum on a bi-weekly basis 2) measure total hydrocarbon concentrations and respirometry gases (O <sub>2</sub> , CO <sub>2</sub> , N) 3) analyze a minimum of 25% of the higher concentrations samples (a consistent set) by GC/FID or GC/MS to obtain an assessment of hydrocarbon composition changes with time.	n/a	0 to 3 Months
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System evaluation	Perform system-wide in situ respirometry test using all the soil gas monitoring points to assess oxygen uptake/aerobic biodegradation rates.	n/a	0 to 3 Months
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	Define the deepest extent of soil impacts	Soil coring in the source zone to better define the vertical extent of soil impacts. Sampling should include full carbon ranges and leachate tests to provide remedial benchmark and assess improvements through time to potential groundwater impacts. Results of this assessment should be combined with existing soil core and CPT/LIF data to verify proper drawdown needed to expose residual LNAPL.	None. KM/LFR indicate that this is in progress as of end of 2004 as a result of an agreement between the City of San Diego and KM.	0 to 3 Months

**Table 1 - Summary of Remedial Milestones – Mission Valley Terminal**

Cleanup Goal	Cleanup Method	Cleanup Task	Cleanup Task Progress Metric	Contingency	Time to Completion
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Ground Water Extraction</b>	Drawdown AND containment of groundwater in the source zone area	<p>Initiate operation of property boundary groundwater containment wells and continued operation of RW-3A/7 extraction wells in the off-property residual LNAPL area.</p> <p>Perform bi-weekly monitoring of water levels throughout the off-property treatment zone. KM/LFR to verify deepest extent of residual LNAPL occurrence based on current data and planned soil coring as described above. This will finalize the amount of additional drawdown required. Current estimate of needed drawdown is 2-5 feet in the off-property source area.</p>	Sufficient drawdown might not be obtained within this time frame; however, operations data and time trends in drawdown should be analyzed to determine if adjustments to pumping rates or numbers of wells are needed to achieve sufficient drawdown within 6 months. Higher pumping rates and/or additional groundwater extraction wells may be required.	0 to 3 Months
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System evaluation and monitoring	Operate SVE system at design flow rate of 1000 ft <sup>3</sup> /min from SVE wells. Verify by weekly measurement of total measured flows from individual SVE wells and total, undiluted SVE system flow rate measurement.	n/a	3 to 12 months
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System evaluation and monitoring	<p>No less than weekly monitoring of total hydrocarbon concentrations, vapor flow rates and vacuum at each SVE well.</p> <p>Sample each SVE well monthly and analyze by GC/FID or GC/MS to determine composition changes with time (as assessed by hydrocarbon fractions).</p>	n/a	3 to 12 months
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System coverage monitoring	<p>Continued sampling of all soil gas monitoring points:</p> <ol style="list-style-type: none"> <li>1) at a minimum on a bi-weekly basis</li> <li>2) measure total hydrocarbon concentrations and respirometry gases (O<sub>2</sub>, CO<sub>2</sub>, N)</li> <li>3) analyze a minimum of 25% of the higher concentrations samples (a consistent set) by GC/FID or GC/MS to obtain an assessment of hydrocarbon composition changes with time.</li> </ol>	n/a	3 to 12 Months

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Cleanup Goal	Cleanup Method	Cleanup Task	Cleanup Task Progress Metric	Contingency	Time to Completion
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System evaluation and monitoring	Optimize vapor flow rates from SVE well network on a weekly basis.  Demonstrate at least bi-weekly that each SVE soil gas monitoring point is: 1) under vacuum at all depths; 2) exposed to vapor flow, not water saturated; 3) sufficiently aerated by the vapor flow such that O <sub>2</sub> concentrations exceed 10% v/v at all depths at each location.	Increase SVE well density or alternate technology should be pursued if ANY of these criteria cannot be met.  Soil vapor monitoring wells must be sealed between sampling events and sampling should be done to ensure no leakage of atmospheric air.	3 to 12 months
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System evaluation and monitoring	Perform system-wide in situ respirometry test using all the soil gas monitoring points to assess oxygen uptake/aerobic biodegradation rates.	n/a	3 to 12 months
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Ground Water Extraction</b>	Drawdown AND containment of groundwater in the source zone area	Verify that necessary dewatering has been achieved in the off-property source zone. Water levels should be at least 1-2 feet below the deepest soil impacts. Show sufficient drawdown by: 1) groundwater level measurements, and; 2) the ability to extract vapors from the deepest soil gas sampling points.	If sufficient drawdown can not be obtained within 6 months, higher pumping rates and/or additional extraction wells will be required.	3 to 12 months
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System evaluation and monitoring	Operate SVE system at design flow rate of 1000 ft <sup>3</sup> /min from soil vapor extraction wells UNLESS it can be demonstrated that aerobic biodegradation rates greatly exceed volatilization rates. If this is true, then extraction flow rates may be reduced, as long as O <sub>2</sub> concentrations exceed 10% v/v at all depths at each soil gas sampling location.	n/a	12 to 60 months
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System evaluation and monitoring	No less than weekly monitoring of each SVE well for: 1) total hydrocarbon concentrations; 2) vapor flow rate 3) vacuum.  No less than monthly sampling at each SVE well, analysis by GC/FID or GC/MS to determine composition changes with time (as assessed by hydrocarbon fractions).	At this point in time, a compositional shift towards the heavier hydrocarbon fractions should be evident. If not, additional SVE wells or application of alternate technology should be implemented.	12 to 60 months

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Cleanup Goal	Cleanup Method	Cleanup Task	Cleanup Task Progress Metric	Contingency	Time to Completion
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System coverage monitoring	Continued sampling of all soil gas monitoring points: 1) at a minimum on a bi-weekly basis 2) measure total hydrocarbon concentrations and respirometry gases (O <sub>2</sub> , CO <sub>2</sub> , N) 3) analyze a minimum of 25% of the higher concentrations samples (a consistent set) by GC/FID or GC/MS to obtain an assessment of hydrocarbon composition changes with time.	n/a	12 to 60 Months
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System evaluation and monitoring	Optimize vapor flow rates from SVE well network on a weekly basis.  Demonstrate at least bi-weekly that each SVE monitoring point is: 1) under vacuum at all depths; 2) exposed to vapor flow, not water saturated; 3) O <sub>2</sub> concentrations exceed 10% v/v at all depths at each soil gas sampling location.	Increase SVE well density or alternate technology should be pursued if ANY of these criteria cannot be met.	12 to 60 months
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Vapor Extraction</b>	SVE System evaluation and monitoring	Perform system-wide in situ respirometry test using all the soil gas monitoring points to assess oxygen uptake/aerobic biodegradation rates.	n/a	12 to 60 months
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Ground Water Extraction</b>	Drawdown AND containment of groundwater in the source zone area	Verify that necessary dewatering has been achieved in the off-property source zone. Water levels should be at least 1-2 feet below the deepest soil impacts. Show sufficient drawdown by: 1) groundwater level measurements, and; 2) the ability to extract vapors from the deepest soil gas sampling points.	If sufficient drawdown is not achieved, higher pumping rates and/or additional extraction wells are required.	12 to 60 months

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Cleanup Goal	Cleanup Method	Cleanup Task	Cleanup Task Progress Metric	Contingency	Time to Completion
<b>Off-Property Residual LNAPL Cleanup</b>	<b>Soil Sample Validation</b>	Access SVE remedial progress	At least every 2 years, conduct soil sampling in the source zone to assess the effectiveness of the SVE remediation. Analysis should include TPH and TPH composition (as expressed by carbon ranges) analyses and lab leachate tests (analysis of leachate for dissolved chemicals of concern) to compare with initial soil samples and assess improvements to potential groundwater impacts with time.	<p>Increase SVE well density or alternate technology should be pursued if remedial progress is not adequate.</p> <p>Within 24 months order-of-magnitude reductions in soil and leachate concentrations, and obvious composition shifts in TPH residuals to heavier compounds should be observed.</p> <p>Within 60 months, soil TPH concentrations should be reduced to below 100 mg/kg and leachate concentrations of chemicals of concern should have decreased to levels less than 10 times the target action levels for each of those chemicals.</p>	12 to 60 months

**Table 1 - Summary of Remedial Milestones – Mission Valley Terminal**

Cleanup Goal	Cleanup Method	Cleanup Task	Cleanup Task Progress Metric	Contingency	Time to Completion
<b>Containment and Cleanup of the Off-property Dissolved Plume: RW-8 and RW-9 "Capture Zone"</b>					
<b>Containment</b>	<b>Ground Water Extraction</b>	Contain groundwater downgradient of off-property source zone	<p>The property boundary containment wells will be put in operation in 1/05.</p> <p>1) Verify that RW-8/9 are providing complete capture downgradient of the off-property source zone. This includes areas beneath and east of the stadium footprint. The RWQCB understands that LFR/KM are in the process of adding wells to the monitoring network for this purpose.</p> <p>2) Monitor effects of the property boundary containment wells on the RW-8/9 containment by collecting water levels within the capture zone monthly for the first 6 to 12 months of operation of the property boundary containment wells. Groundwater flow directions which trend toward the extraction wells and encompass the entire plume area should be maintained. Well coverage should be sufficient to demonstrate completeness of capture.</p>	If complete groundwater capture downgradient of the off-property source zone can not be adequately demonstrated - add wells to monitoring network and/or install additional extraction well(s)	0 to 6 months

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Cleanup Goal	Cleanup Method	Cleanup Task	Cleanup Task Progress Metric	Contingency	Time to Completion
<b>Groundwater Cleanup</b>	<b>Ground Water Extraction</b>	Remediate groundwater within the RW-8/9 capture zone	<p>Assuming the combination of the property boundary containment wells and the existing extraction wells within the off-property source area (RW-3A to 7) are successful at exposing all residual LNAPL, and that no residual LNAPL remains within the saturated zone, then the practical function of RW-8/9 will also be to remediate this portion of the MTBE plume.</p> <p>Extraction rates at RW-8/9 should be sufficient to maintain the previously calculated 4-year residence time for one pore volume (~60 gpm combined). Modeling suggests that pumping in tandem with presumed natural biological processes will bring this portion of the MTBE plume to concentrations less than or equal to 10 µg/L within this timeframe. TBA should also be below action levels within this time frame.</p> <p>There is strong suggestion by KM/LFR that biodegradation of MTBE may be occurring in portions of the plume. Since this may be a component of the overall remedial action, and since the actual processes responsible are not well understood at this time, all parameters which would indicate either aerobic or anaerobic biodegradation should continue to be monitored. This would include pH, DO, alkalinity, methane, ferrous iron, sulfate and nitrate. It is anticipated that a more complete understanding of the MTBE-degrading biological processes will develop during this time period and it may therefore be appropriate to modify reporting requirements accordingly.</p>	<p>During this time period, quarterly groundwater monitoring will proceed. Data should show:</p> <ol style="list-style-type: none"> <li>1) groundwater flow gradients and directions which demonstrate continued and full hydraulic capture of this portion of the plume, and</li> <li>2) continuously decreasing concentrations of MTBE and TBA.</li> </ol> <p>If groundwater concentrations do not continue to trend downward, additional extraction wells may be installed or an additional remedial technology may need to be implemented.</p>	6 to 60 months

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<b>Cleanup Goal</b>	<b>Cleanup Method</b>	<b>Cleanup Task</b>	<b>Cleanup Task Progress Metric</b>	<b>Contingency</b>	<b>Time to Completion</b>
<b>Groundwater Cleanup</b>	<b>Ground Water Extraction</b>	Reduction/ Elimination of pumping at RW-9	Pumping at RW-9 may be reduced or turned off once the plume downgradient of RW-8 is at or below action levels. KM/LFR may wish to assess this option during the latter portion of the 60-month time period.	RW-9 to remain on for entire time period if remedial data does not suggest this portion of the capture zone has been reduced to action levels before 60-months.	at or before 60 months
			It is anticipated that by the end of the 60-month time period, the MTBE/TBA plume downgradient of RW-8 will be below action levels and pumping at RW-9 can be gradually reduced to 0.	If groundwater concentrations downgradient of RW-8 increase, pumping at RW-9 may be re-started.	60-96 months
<b>Groundwater Cleanup</b>	<b>Ground Water Extraction</b>	Reduction/ Elimination of pumping at RW-8	<p>It is anticipated that at 60-months, the SVE system will have effectively treated the vadose zone within the off-property source area. As groundwater levels are allowed to rise back into the zone where residual LNAPL occurred, it is possible that some re-bound contamination of groundwater may occur. Although this may be captured by the RW-3A/RW-7 line of extraction wells, RW-8 should continue to operate through this phase to provide containment and capture of any dissolved contamination which is outside of the influence of the RW-3A/RW-7 extraction well group.</p> <p>If groundwater concentrations within the RW-8 capture area are maintained below action levels, it would be appropriate to reduce and gradually end pumping at RW-8.</p>	If groundwater concentrations within the RW-8 capture zone go up once the active SVE remediation of the off-property LNAPL area is ended, RW-8 may need to operate through this entire period.	60-96 months

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<b>Cleanup Goal</b>	<b>Cleanup Method</b>	<b>Cleanup Task</b>	<b>Cleanup Task Progress Metric</b>	<b>Contingency</b>	<b>Time to Completion</b>
<b>Groundwater Cleanup</b>	<b>Ground Water Extraction</b>	RW-3A through RW-7 pumping	It is anticipated that extraction wells RW3A/RW-7 will have continued to operate throughout the 96 months.	If action levels cannot be obtained in the off-property source area within the 96-month time frame, and it cannot be shown that the property boundary containment wells will sufficiently contain any areas of groundwater still impacted by residual LNAPL, then one or more of these wells may need to be operated on a long-term basis.	Post-96 months
<b>Groundwater Cleanup</b>	<b>Ground Water Extraction</b>	Property Boundary Containment Wells	The property boundary containment wells will operate on a long-term basis to contain dissolved contaminants emanating from on-property LNAPL areas.	If at any time it is apparent that the property boundary containment wells are not providing sufficient capture to prevent any off-property migration of either dissolved or LNAPL phase from existing or future releases, additional extraction wells may be required.	Long-term.
<b>Containment and Cleanup of the Off-property Dissolved Plume: Downgradient of RW-8 and RW-9 "Capture Zone"</b>					
<b>Groundwater Cleanup/ plume definition</b>	<b>Natural Attenuation</b>	Plume definition downgradient of RW-9	It is estimated that over half the volume of the dissolved plume currently exists downgradient of any active groundwater capture and treatment system. Within this time frame, KM/LFR are to install a more robust monitoring network to determine the actual location of the plume, and define the areas of higher concentration which appear to be narrower than can be determined by the current well spacing.	If additional wells planned by KM/LFR do not provide adequate data to assess and monitor this portion of the plume, additional monitoring points may be required.	0 to 18 months

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Cleanup Goal	Cleanup Method	Cleanup Task	Cleanup Task Progress Metric	Contingency	Time to Completion
<b>Groundwater Cleanup</b>	<b>Natural Attenuation</b>	Remediate portion of plume downgradient of RW-9	<p>Similar to the area within the RW-8/9 capture zone, there is strong suggestion in this portion of the MTBE/TBA plume that some biodegradation may be occurring. Since biological action is a principal remedial component of natural attenuation, and since the actual processes responsible are not well understood at this time, all parameters which would indicate either aerobic or anaerobic biodegradation should continue to be monitored, including pH, DO, alkalinity, methane, ferrous iron, sulfate and nitrate.</p> <p>It is anticipated that a more complete understanding of the MTBE-reducing biological processes will develop during this time period and it may therefore be appropriate to modify reporting requirements accordingly.</p>	If groundwater data do not suggest that this portion of the plume will attenuate to within action level concentrations within 5 years, some active remedial measure may be required.	18 to 60 months
<b>Contingency for Potential Municipal Well Installations Adjacent to San Diego River</b>					
<b>Contingency</b>	<b>Contingency for wellhead treatment</b>	Contingency for residual dissolved phase concentrations to impact future municipal wells	Given current uncertainties in the configuration of the MTBE/TBA plume, and the uncertainties regarding the timing, location and design of a potential municipal pumping well, it is impossible to gauge with certainty what impacts the dissolved plume might have on any potential municipal well.	At such time as a well location and design is decided upon by the City, a technical evaluation should be done to determine if a portion of the plume existing at that time will be captured by the municipal well. If the evaluation suggests that the well will be impacted by the remaining groundwater plume, then wellhead treatment should be considered as a remedial option.	Undetermined time frame